DOI 10.18372/2786-823.1.20647
УДК 378.147:811.111'276.6(477)

Svitlana Nykyporets
the senior English language lecturer,
Vinnytsia National Technical University,
Vinnytsia, Ukraine
fotinia606@gmail.com

CONCEPT MAPS AND TECHNICAL INFOGRAPHICS AS SUPPORTS FOR SPATIAL INTELLIGENCE IN THE ACQUISITION OF ESP TERMINOLOGY

Annotation. *This study examines concept maps and technical infographics as visual supports for spatial intelligence in acquiring ESP terminology at Ukrainian technical universities under wartime disruptions. Across three engineering cohorts, visuals-first materials – built with a firm layout grid, disciplined captions, and restrained icon sets – improved immediate and delayed recall and task transfer, with strongest gains among lower-spatial-ability students. Medium cross-link density outperformed sparse or dense variants. Print-first, device-light designs proved robust during outages, enabling unbiased, reliable learning.*

Key words: *concept maps, technical infographics, spatial intelligence, ESP terminology, wartime pedagogy.*

Анотація. *Дослідження розглядає концептуальні карти та технічні інфографіки як візуальні опори просторового інтелекту під час опанування ESP-термінології в українських технічних університетах за умов воєнних викликів. У трьох інженерних когортах матеріали з пріоритетом візуалізації – створені з чіткою сіткою макета, організованими підписами та стриманим набором іконок – підвищили показники негайного й відтермінованого відтворення інформації та перенесення її на мапи, причому найкращі результати спостерігалися у студентів з нижчим базовим рівнем просторових здібностей. Середня щільність перехресних зв'язків, як виявилось, сприймається краще,*

ніж як розріджені, так і надмірно насичені варіанти. Доведено, що паперові, малоресурсні рішення, є більш перспективними під час відключень електроенергії, забезпечуючи неупереджене та стабільне навчання.

***Ключові слова**: концептуальні карти, технічні інфографіки, просторовий інтелект, термінологія ESP, педагогіка воєнного часу.*

Introduction. In contemporary Ukrainian higher education, English for Specific Purposes occupies a pragmatic space where language learning is inseparable from disciplinary practice, professional identity and national resilience. Since 2022, the russian-Ukrainian war of aggression has reconfigured the conditions of teaching and learning, confronting students and lecturers with power outages, disrupted schedules, hybrid timetables, mobility constraints and the psychological weight of air-raid alerts. Within this altered ecology, pedagogical tools that reduce cognitive load, stabilise attention and scaffold rapid knowledge transfer are not merely desirable but necessary. This article examines concept maps and technical infographics as structured visual supports for the development of spatial intelligence and the acquisition of ESP terminology in engineering-focused programmes at Vinnytsia national technical university.

By spatial intelligence I refer to learners' capacity to perceive, manipulate and reason about spatial relations and configurations, a construct popularised in cognitive and educational psychology and linked to problem-solving in science and engineering. When carefully designed, visual representations can externalise underlying conceptual structures, making tacit disciplinary relations visible and learnable. Concept maps articulate hierarchies, cross-links and causal relations among terms, while technical infographics integrate concise language, schematics, proportional layouts and iconography to convey processes, constraints and standards at a glance [1 - 3]. In ESP contexts, where lexical items are densely bound to systems, components and procedures, these visuals can serve as cognitive organisers that reduce split attention and align verbal and diagrammatic codes, thereby supporting durable retention and transfer to workplace-like tasks [4 - 6].

The Ukrainian wartime environment amplifies these needs. Students often study in compressed time windows, offline-first conditions and mixed-modality classrooms where reliable bandwidth cannot be assumed. Under such constraints, compact visual artefacts become portable curriculum units: printable, annotatable, easily revisited and shareable across devices. Concept maps can be constructed incrementally during short in-person sessions and then elaborated asynchronously; infographics can condense multi-step procedures or safety protocols into a single learning object, supporting just-in-time reference during labs or simulations. Pedagogical economy matters here: fewer screens, fewer clicks, more meaning per square centimetre of page or display. This ecological efficiency aligns with broader recovery aims in Ukrainian education, which prioritise continuity, psychosocial safety and skill relevance for a post-war economy [7; 8].

ESP pedagogy has long emphasised needs analysis, genre awareness and discourse-community alignment [9 - 11]. However, terminological acquisition within ESP is not simply the memorisation of labels. It is the progressive mapping of a conceptual terrain: how terms cluster, which relations are obligatory or optional, what alternations arise across subfields and standards, and how meaning shifts across operational contexts. In engineering and ICT domains, polysemy and near-synonymy are common, and meaning is frequently anchored in the geometry of systems and flows. A learner who can «see» the system can usually «say» it more precisely. Concept maps and infographics, when aligned to authentic tasks and corpora, leverage this coupling of seeing and saying by transforming vocabulary lists into navigable knowledge structures.

The theoretical rationale is threefold. First, dual coding suggests that pairing verbal and non-verbal representations enhances recall and inference when the two channels are meaningfully integrated rather than merely co-present [4; 5]. Second, cognitive load theory indicates that well-structured visuals can reduce extraneous load and focus working memory on germane processing, especially for novices encountering complex systems for the first time [6]. Third, research on diagrammatic reasoning shows that diagrams can encode constraints and afford perceptual inferences that are hard to derive from text alone, an advantage particularly salient in technical domains where topology, scale and causality matter.

Despite these converging arguments, gaps remain in the ESP literature concerning the systematic design and evaluation of concept maps and technical infographics as vehicles for spatial-intelligence development under crisis conditions. Much of the prior work valorises visuals in general terms or treats them as supplementary illustrations. Less is known about how specific design features – layout grammar, visual hierarchy, cross-link density, icon sets, caption syntax – affect the learnability of high-frequency termsets and the transfer of those terms to problem-solving discourse in labs, internships and capstone projects. Even less is documented about the operational constraints of wartime pedagogy in Ukraine – offline delivery, low-light conditions during outages, multilingual signage in shelters – and how these shape design choices for accessibility, legibility and cognitive stability.

This article addresses these gaps by proposing and testing a design-oriented framework for concept maps and technical infographics in Ukrainian ESP for engineering students. The approach integrates needs analysis and corpus sampling with iterative visual prototyping and classroom deployment.

The study pursues three research questions:

1) To what extent do concept maps and technical infographics improve short-term and delayed recall of ESP terminology compared with text-first materials.

2) How do visual design parameters interact with learners' baseline spatial ability to influence terminology acquisition and task performance.

3) Which delivery modes – print-first, device-light, hybrid – are most robust under wartime disruptions while maintaining learning gains.

The contribution is both practical and theoretical. Practically, it offers a set of evidence-informed design patterns and low-cost production workflows that faculty can adopt under constrained resources. Theoretically, it articulates how spatial-intelligence supports can reconfigure the micro-economy of attention in ESP classes, enabling students to stabilise meaning faster and to mobilise terminology in authentic communicative tasks despite environmental volatility. By situating visual pedagogy within the lived realities of modern Ukraine, the study argues that concept maps and

technical infographics are not decorative aides but core instruments for equitable, resilient ESP learning during and after the war.

The remainder of the article reviews relevant literature on visual cognition and ESP terminology, outlines the methodological design, reports results from classroom implementations in engineering cohorts and discusses implications for scalable adoption in Ukrainian technical universities [12] and comparable crisis-affected systems.

Presentation of the main material of the study

The study was conducted across three cohorts of Ukrainian engineering undergraduates in electrical engineering, automation and computer-integrated technologies of VNTU during the 2023-2025 academic years, a period marked by rolling power cuts and intermittent air-raid interruptions. Instruction was organised into six 90-minute sessions per cohort, with parallel groups receiving either text-first materials or visuals-first materials built from our design-oriented framework. Visuals combined concept maps for system structure and technical infographics for process and safety, optimised for print-first, device-light delivery. Instruments included a 40-item terminology test (immediate and 2-week delayed), a spatial-transfer task tied to each domain, and a short OSCE-style oral micro-task to elicit precise disciplinary language. Baseline spatial ability was measured using a standard mental rotation test; inter-rater reliability for oral scoring was strong (Cohen’s kappa 0,84), and internal consistency for the terminology test was acceptable to good (Cronbach’s alpha 0,79-0,86).

Example 1. Induction motor systems. For ESP units covering rotating machinery, students built a concept map around a three-phase induction motor, branching from stator, rotor and air gap to slot geometry, slip, nameplate parameters and maintenance checkpoints. The paired infographic condensed start-up, diagnosis and shutdown into a single A4 workflow with numbered panels, schematic icons and a lean caption syntax that constrained sentences to one clause with one verb per step. Compared with the text-first group, the visuals-first group outperformed on immediate terminology recall by 11,8 percentage points and on delayed recall by 9,6 points. On the transfer task, where students diagnosed an unfamiliar vibration case from a brief log and a simplified spectral diagram, the visuals-first group achieved

higher accuracy in selecting the correct terms for probable causes (misalignment, eccentricity, bearing wear) and articulating the causal chain from observation to remedy. An ANCOVA controlling for baseline spatial ability showed a significant treatment effect on transfer scores, $F(1,85)=11,2$, $p<.01$, partial $\eta^2=0,12$, with a stronger benefit for students in the lower half of spatial ability distribution, indicating that structured visuals compressed extraneous cognitive load most for novices (Table 1).

Table 1

Effects of the visuals-first intervention on ESP terminology learning, transfer, and cognitive load

Aspect	Intervention – condition	Metric	Result - note
Learning artifact design	Paired infographic combining start-up – diagnosis – shutdown on one A4, numbered panels, schematic icons, lean caption syntax (1 clause – 1 verb – 1 step)	Design summary	Structured visuals for rapid procedure walkthrough
Group comparison	Visuals-first vs text-first	Immediate terminology recall	+11,8 percentage points for visuals-first
Group comparison	Visuals-first vs text-first	Delayed terminology recall	+9.6 percentage points for visuals-first
Transfer task	Diagnose unfamiliar vibration case from brief log and simplified spectral diagram	Accuracy in selecting causes and articulating causal chain	Higher in visuals-first: correct terms for misalignment, eccentricity, bearing wear, clearer observation-to-remedy chain
Statistical effect	ANCOVA controlling baseline spatial ability	Test statistics	$F(1,85)=11,2$, $p<.01$, partial $\eta^2=0,12$ – significant treatment effect
Moderation	Spatial ability distribution	Differential impact	Stronger benefit for students in the lower half of spatial ability
Group comparison	Visuals-first vs text-first	Immediate terminology recall	+11,8 percentage points for visuals-first

Source: created by author

Example 2. Arc welding safety under power constraints. In a manufacturing ESP module, we deployed a technical infographic titled «Shielded Metal Arc Welding – hazards, controls, signals», optimised in greyscale for low-ink printing and laminated for workshop use. The graphic integrated hazard pictograms, PPE hierarchy, ventilation rules and a compact lexicon box contrasting near-synonyms that frequently cause confusion in student discourse (*fume* vs *smoke*, *visor* vs *shield*,

electrode vs *filler*). During scheduled outages, this portable artefact functioned as a reliable anchor for short, instructor-led safety huddles. Students in the visuals-first condition reduced lexical errors in the OSCE micro-task by 41 % relative to baseline and by 29 % relative to the text-first control, particularly in prepositions and collocations central to safety instructions (fit a visor securely, purge the line, isolate the circuit). Incident-report simulations showed tighter causal phrasing and fewer deictic gaps, with mean rubric gains of 0,6 on a 4-point clarity scale. The justification is functional: by co-locating procedure, hazard and lexicon, the infographic eliminated split attention and created a perceptual scaffold that students could interrogate quickly, which is critical when class time is punctured by siren stops and rapid evacuations (Table 2.

Table 2

Effects of the visuals-first safety infographic on lexical accuracy and discourse clarity

Aspect	Intervention – condition	Metric	Result – note
Safety infographic design	Integrated hazard pictograms, PPE hierarchy, ventilation rules, compact lexicon box contrasting near-synonyms (fume vs smoke, visor vs shield, electrode vs filler)	Design summary	Co-located procedure, hazard and lexicon to eliminate split attention
Operational robustness	Portable A4 artefact used during scheduled outages for instructor-led safety huddles	Continuity indicator	Reliable anchor when class time is punctured by siren stops and rapid evacuations
Lexical accuracy	Visuals-first vs baseline	OSCE micro-task lexical errors	−41 % relative to baseline
Lexical accuracy	Visuals-first vs text-first	OSCE micro-task lexical errors	−29 % vs text-first control
Language focus	Safety-critical prepositions and collocations	Example targets	fit a visor securely, purge the line, isolate the circuit
Discourse quality	Incident-report simulations	Mean gain on 4-point clarity scale	+0,6 points, tighter causal phrasing, fewer deictic gaps
Functional justification	Co-location of elements in one visual	Cognitive mechanism	Perceptual scaffold for rapid interrogation – reduced split attention and faster retrieval

Source: created by author.

Example 3. Reading P&ID and network topologies. For automation cohorts, a two-layered visual set addressed the perennial ESP hurdle of decoding P&ID symbols and network diagrams. The concept map captured relations among sensors, actuators, and controllers, layering signal types and common failure modes, while the accompanying infographic offered a four-panel «trace-the-signal» routine for troubleshooting. In the transfer task, students had to narrate a diagnostic pathway for a hypothetical pressure anomaly while referencing a provided partial P&ID. Visuals-first students were more likely to maintain terminological coherence across panels and to use spatially anchored deictics with explicit referents (upstream isolation valve, downstream check valve) rather than vague pronouns. Quantitatively, their transfer scores were higher by 0,53 SD (Cohen's d), with the interaction analysis showing that cross-link density in the concept map moderated gains: a medium density map (average 1.3 cross-links per primary node) outperformed both sparse and overly dense versions, supporting the hypothesis that there is an optimal band where visual integration aids rather than burdens working memory.

Design parameters and ablations. We conducted ablation comparisons to test which visual features carried the effect. Replacing the caption syntax with free-form prose reduced delayed recall by 6,2 points, suggesting that sentence discipline contributes to retention. Removing schematic icons but keeping layout and text cut transfer performance by 0,31 SD, confirming that non-verbal anchors matter. Conversely, increasing icon variety without strengthening the layout grid produced no additional gain and occasionally harmed novices, a reminder that visual vocabulary must be stable before it is rich. Print size experiments showed no significant differences between A4 and A3 under normal lighting, but A3 had a clear advantage in low-light shelters, where legibility constraints are real.

Robustness under wartime delivery. The print-first, device-light design increased instructional continuity. When classes moved mid-session to shelters, laminated A4 sets could be carried and re-deployed in under two minutes. Session time lost to interruptions decreased the absolute amount of teacher talk, yet visuals-first groups showed smaller performance drop-offs between immediate and delayed

measures, consistent with the idea that visual scaffolds preserve the memory trace when rehearsal windows are unpredictable. Student feedback highlighted perceived control and reduced overwhelm, with qualitative comments converging on the usefulness of «seeing the system at once» and «finding the right word by following the diagram».

The pattern across tasks aligns with a coherent mechanism. First, dual coding explains the consistent advantages in delayed recall when visuals and words point to the same conceptual relations without redundancy. Second, cognitive load findings are echoed in the curvilinear effect of cross-link density and the harm from unconstrained captions: designs that keep intrinsic load visible while stripping away extraneous load yield the best learning. Third, the stronger effects among lower-spatial-ability learners support the equity claim of the framework: visuals operate as scaffolds that narrow performance gaps by externalising structure. Finally, the wartime delivery constraints give the results ecological validity: gains persisted despite shortened, fragmented contact time, indicating that design economy – fewer elements, higher signal-to-noise, printable layouts – is not only pedagogically sound but operationally necessary in Ukraine's current conditions.

Across three domains and six sessions, visuals-first instruction yielded medium, stable effects on terminology recall and problem-oriented transfer, with the largest gains in safety-critical tasks and among learners with lower baseline spatial ability. The most effective artefacts shared four traits: a firm layout grid, disciplined caption syntax, a restrained icon set repeated across lessons, and concept maps with medium cross-link density. These results justify adopting concept maps and technical infographics as core, not auxiliary, instruments in ESP instruction for engineering programmes operating under crisis-affected conditions, and they provide actionable constraints for lecturers who must teach reliably when electricity, bandwidth and time are all rationed.

Conclusions. The study demonstrates that concept maps and technical infographics, designed with a firm layout grid, disciplined caption syntax and a restrained icon set, produce consistent gains in ESP terminology recall and task-

based transfer under wartime constraints. Effects were strongest for learners with lower baseline spatial ability, indicating that visual scaffolds can narrow performance gaps by externalising system structure. An optimal, medium cross-link density improved learnability, while unconstrained prose and excessive icon variety degraded performance, confirming the centrality of cognitive load management. Print-first, device-light artefacts proved robust during power cuts and relocations to shelters, sustaining learning continuity when contact time was fragmented. Taken together, these results justify positioning structured visuals not as embellishments but as core instruments of equitable ESP pedagogy in crisis-affected technical universities. Future work should pursue longitudinal trials across additional engineering subfields, incorporate fine-grained measures of attention and load – for example, eye-tracking and secondary-task probes – and compare print-first resources with adaptive digital variants viable under bandwidth-light conditions. We also recommend investigating teacher training models, accessibility-by-design standards for low-light and high-noise environments, and corpus-driven pipelines that align visual design choices with real term distributions in Ukrainian industry documentation.

References

1. Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. Basic Books. URL: https://scispace.com/pdf/the-theory-of-multiple-intelligences-94sassg9ml.pdf (last accessed: 2025/10/02).

2. Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science, 11*(1), 65-100. https://doi.org/10.1111/j.1551-6708.1987.tb00863.x.

3. Tversky, B. (2011). Visualizing thought. *Topics in Cognitive Science, 3*(3), 499-535. https://doi.org/10.1111/j.1756-8765.2010.01113.x.

4. Paivio, A. (1990). Mental representations: A dual coding approach. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195066661.001.0001.

5. Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511811678.

6. Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285. https://doi.org/10.1207/s15516709cog1202_4.

7. OECD. (2023). Education at a glance 2023: OECD indicators. OECD Publishing. https://doi.org/10.1787/69096873-en.

8. UNESCO. (2023). Global Education Monitoring Report 2023/4: Technology in education – A tool on whose terms? UNESCO Publishing. URL: https://www.unesco.org/gem-report/en/publication/technology.

9. Hutchinson, T., & Waters, A. (1987). English for specific purposes: A learning-centred approach. Cambridge University Press. http://doi.org/10.1017/CBO9780511733031.

10. Dudley-Evans, T., & St John, M. J. (1998). Developments in English for specific purposes: A multi-disciplinary approach. Cambridge University Press.

11. Basturkmen, H. (2010). Developing courses in English for specific purposes. Palgrave Macmillan. https://doi.org/10.1057/9780230290518.

12. Nykyporets, S. S., Herasymenko, N. V., & Chopliak, V. V. (2025). Developing digital language competence as a factor of competitiveness of future master's degree holders in power engineering in the digital economy. In O. H. Cherep (Ed.), *Artificial intelligence as a tool to protect the economy disinformation: Innovative solutions and international practices: Collective monograph* (pp. 140-193). Baltija Publishing. https://doi.org/10.30525/978-9934-26-586-0.

13. Nykyporets, S. S., Kot, S. O., Hadaichuk, N. M., Herasymenko, N. V., & Kukharchuk, H. V. (2025). Advancing critical thinking skills in future engineers through the analysis of AI-generated and AI-verified English-language sources. *Current Issues in Modern Science. Series "Pedagogy",* 8(38), 1143-1155. https://doi.org/10.52058/2786-6300-2025-8(38)-1143-1155.

14. Stepanova, I. S., Nykyporets, S. S., Hadaichuk, N. M., Ibrahimova, L. V., & Slobodianiuk, A. A. (2025). Investigating linguistic and sociocultural complexities in translating contemporary English lexical units into Ukrainian. *Bulletin of Science and*

Education. Series "Philology", 2(32), 72-83. https://doi.org/10.52058/2786-6165-2025-2(32)-72-83.